Systemic Design Path to Innovate Italian Archaeological Museums into Hybrid Museums

Alessandro Mucci

Istituto Superiore per le Industrie Artistiche - ISIA Pescara Design,
Multimedia Design - Sistemi per la Comunicazione Multimediale

* Corresponding author's email: alessandro.mucci@isiadesign.pe.it

ABSTRACT

The paper traces a methodological path to innovate the communication and visitor's experience of Italian cultural heritage museums, converting them into hybrid museums by adopting a systemic design approach. Starting with an overall social and technological context observation, this design path defines both the scenario in which analyze users' interaction with the museum system and the principles for innovation strategies that could allow museums to remain relevant in a contemporary context. Insight and intervention hints have been acquired by a qualitative analysis comparing Museo Archeologico Nazionale d'Abruzzo (MANA) to other similar national and international archaeological museum organizations in order to address this case study's challenges through innovation projects. The project proposes itself as a practical case study or possible reference for designers involved in museum innovation, covering the whole museum system and exploring a possible solution to create a more active dialogue between visitors and exhibit. Each system's component has been designed with a holistic perspective that enhances the relationship between these projects' elements, considering them indivisible and not effective as independent interventions. Therefore, the study delves into the development of a narrative mixed reality experience concerning the Warrior of Capestrano statue, relating it to the museum's digital touchpoints that have been improved through a redesign process of visual communication. The key result is a practical design path dedicated to designers for museum innovation, along with an adaptable workflow for creation of narrative mixed reality contents about archeological finds.

Keywords: hybrid museum, museum innovation, digital storytelling.

1 Introduction

The evolving relationship between individuals and technology constantly changes social and interaction behaviors, inducing the cultural heritage museum system to comply with this ever-transforming process led by digital technology media by adopting user-centered approaches that emphasize visitors' agency[1, 2]. These dynamic relationships affect both communication and museum experience as proved during the pandemic period, in which the digital transition process of historical and artistic heritage has been accelerated in order to bypass physical constrictions[3, 4]. Successful strategies have been deployed in order to offer engaging experiences and contents to audiences through the digital universe, but this unexpected scenario has brought side effects due to the lack of a clear vision on physical and digital experience in post-pandemic museum visits. In this context, many Italian museums employed different channels to host digital contents without a consistent approach to innovation or a clear vision of possible integration paths in the post-pandemic period. As a result, Italian museum innovation proceeds slowly and discontinuously due to the inability of many institutions to take advantage of digital technologies potential and their expressive possibilities or storytelling opportunities, often failing to intercept visitors' expectations[5]. This study aims to provide a practical design path showing to designers how communication and experience projects could be managed in a systemic way, employing a comparative analysis to find insight and innovation strategies

through parallelism between museum organizations to address critical issues of an Italian archaeological museum selected as case

2   General context

The rapid evolution of internet during the 90s and mass diffusion of personal computers in the early 2000s significantly changed the access to information and its production[6, 7]. As described by Delfanti (2013), the dynamics of the collaborative web setted users on an active role towards information, transforming them into prosumers[8], or rather those who both consume and produce contents[9]. The prosumers profile changed along with technology that significantly affected their social behaviors and interactions, as well as they took an active role in digital service development[10]. Nowadays, the physical and digital dimensions keep influencing each other[11] moving closer thanks to users' activities, creating a continuum between the two dimensions in which physical reality is extended by virtual one[12]. Even the cultural heritage environment adapted its museum design paradigms[13] shifting the attention from collections to visitors and their agency[14]. In fact, museums propose nowadays more visit experiences based on storytelling of the exhibits through different media, taking care of visitor's point of view and participation in order to keep their engagement[15] high during the visit. This design approach is largely employed by Hybrid Museums alongside technologies that are used to augment, expand or alter the physical experience of visiting museums[16]. Furthermore, hybrid museum experiences involve technology not just as a trend but for its flexible support of the user's meaning-making process towards an exhibit[17], mediating between physical and virtual layers.

2.1   The Italian museum context

The social changes mentioned in the previous paragraph also impacted the Italian culture system that is benefiting from more visibility and engagement of the audience thanks to new tools and communication channels offered by digital technologies. Bonacini (2014) stated how Italian cultural institutions and museums have been modernized thanks to technologies, pointing out that the innovation process is a continuous work in progress[18] but, although regulations and guidelines were provided to manage the innovation of the cultural sector[19], this process is discontinuous due to several difficulties that museums are often unable to address. The lack of dedicated professional figures or the absence of a strategic plan for digital innovation represent just a part of many issues reported by museums[20] and moreover, the cultural system is not fully aware of the use and potential of digital technologies [21] and it had to deal also with the effects of several forced choices driven by constriction during the pandemic period. Even though the digitalization process had received a significant boost, the innovation of cultural heritage was managed without a real systemic design approach or a clear vision of possible design paths in post-pandemic time.

2.2   User of the museum system

Instead of delving into user persona profiles, a brief description of relevant users' role and interaction towards the museum system has been provided and they are defined as follows: youth, digital artists, designers, institutions. The youth visitors are part of a wider target and they are involved in the meaning-making process towards the cultural heritage as well as their activities of sharing contents while the institutions facilitate and support cultural related events and projects. Digital artists and designers are more relevant from the viewpoint of this design approach because the first ones create new multimedia contents expanding the meaning and the interpretation of the exhibit, while the seconds manage these contents designing new experience paths and providing innovation strategies.

2.3   Case study and comparative analysis

The Museo Archeologico Nazionale d'Abruzzo, generally shortened as MANdA but renamed MANA in this study, is located in Chieti (Abruzzo, Italy) and it holds a precious collection of archaeological finds from Italic and Roman populations who inhabited the region in past eras. It has been chosen as a case study for this methodology application because of its lack of visual identity and proper digital touchpoints, such as website or social media channels. Moreover, MANA communication totally depends on the culture ministerial regional website that presents just a few 3D scans of finds missing a real strategy to engage visitors, also reflected by the classical visit experience limited to guided tours, informative panels and descriptive audio guides. As previously mentioned in paragraph 2.1, the national regulations don't provide any detailed plans or specific guidelines for designers, so the qualitative comparative analysis aimed to fill the gap by collecting ideas and innovation practices, comparing MANA to similar institutions and obtaining a set of interventions that could be adapted to it in order to improve its communication and visit experiences. The comparison immediately pointed out that, differently from the MANA, almost all museums or cultural organizations own dedicated digital touchpoints in which they apply different communication strategies promoting upcoming events, visit experiences, insights about collection or topics related to the exhibit that could engage visitors. Except for a few institutions that still present classical visits, all examined museums have already approached at least digital experiences integrating them into their visit path. Parco Archeologico dell'Appia Antica (Rome)[22], Museo Egizio (Turin)[23] and Muséum National d'Histoire naturelle (Paris)[24] are the most relevant cases because they propose hybrid experiences based on storytelling, immersive exhibits, mixed reality applications or gamification. Furthermore, each organisation presented a unique visual identity project with strong branding characteristics that enhanced the communication of their vision, mission and values while revealing a visual consistency through all touchpoints. The most relevant cases for this aspect are Museo Nazionale d'Abruzzo[25], Museo Nazionale Romano[26], CAST Musei Civici di Pavia[27] and The British Museum[28].

3   Design outputs

Several critical issues and the gap emerging from comparative analysis suggested the necessity of an intervention covering the whole MANA museum system and, in particular, a focus on innovating visit paths approaching hybrid experience and digital storytelling. More engagement and interest towards the museum and its exhibit should be created in doing so, as well as the project should lay the fundamentals for a dialogue that guides visitor's personal meaning-making process of cultural heritage[29, 30, 31, 32] of Abruzzo region. Moreover, a renovation of the whole communication is necessary and it should start from the designing of a visual identity consistent through all digital and physical museum touchpoints, also reflecting the MANA's vision and values to visitors, as well as promoting events, exhibits and related topics[33]. For this case study, each design output shown below in Figure 1 has been developed using a holistic design approach that linked them to each other, focusing on interactions between the whole system and its parts and enhancing their synergic relationship, considering all of them indivisible and not effective as independent projectual interventions. In order to show the result of this approach, the paper delves into the narrative hybrid experience concerning one of the most important archeological finds of MANA and then proposes a new visual identity that supports the hybrid experience through digital touchpoints as mobile museum app and website.
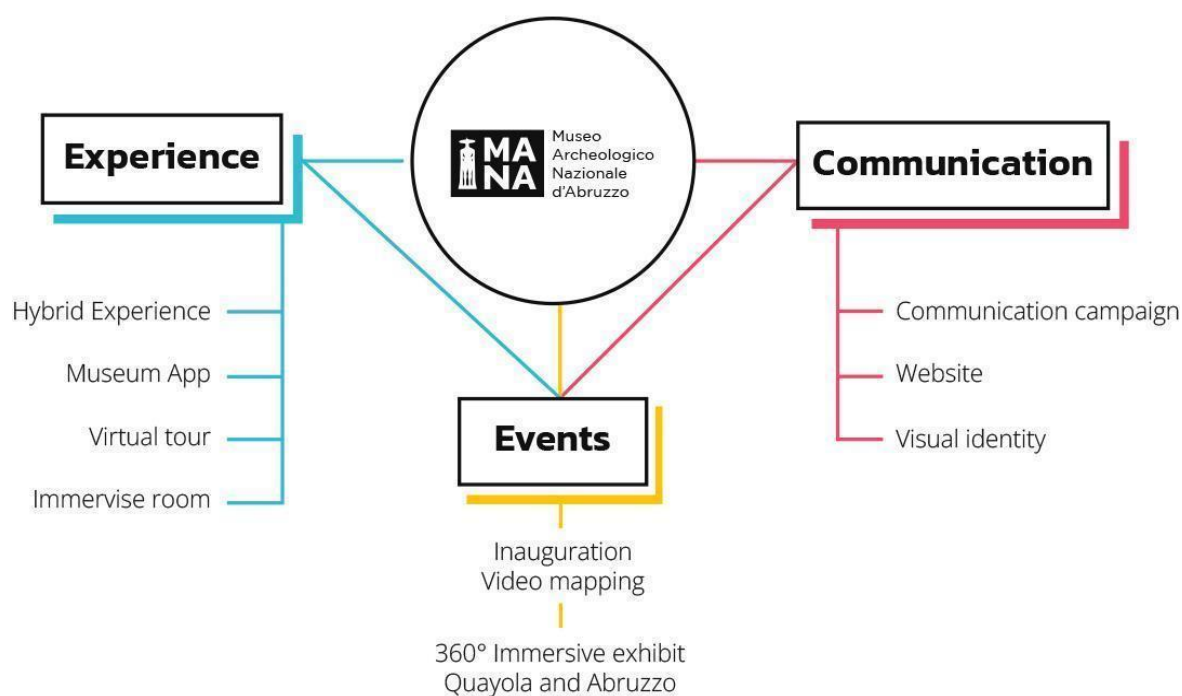
Figure 1: *Scheme representing all the system output designed for the renovation project*

4   The narrative hybrid experience

The Warrior of Capestrano is the most important statue of Italic art and it represents an inestimable legacy from Vestini, one of the population who inhabited Abruzzo in past eras, and it is the subject of this hybrid experience. The MANA shows the statue in a permanent exhibit designed by the artist Mimmo Paladino that enhances only the artistic and formal aspect of the sculpture removing any kind of historical reference[34]. The current exhibit couldn't be modified, so the role of mixed reality is to bypass this physical constriction by narrating a story about the Warrior while a virtual layer shows contents not available in other ways, giving back the historical connotations of the statue. The experience is developed employing a multidisciplinary path made up of the storytelling process and the prototyping of both virtual content and mixed reality hosted by a mobile application.

4.1   Storytelling process

Lambert's "Seven Steps"[35] framework was the reference for this storytelling process but it has been adapted into five phases as follows: researching information, defining narrative scheme, writing the story, creating storyboard, recording voiceover (or narrative voice). Archaeological information has been gathered from the museum's archives consulting the most relevant volumes and journals[36, 37] related to Capestrano Warrior's figure, his role in Vestini's society, the iconographic and symbolic meaning of his memorial statue. Search time has been optimized in this way by focusing on general aspects of the statue and avoiding unnecessary materials. This information, then, has been filtered according to the museum archeologist's opinion, selecting the most meaningful one for visitors and, at the same time, those which could be more adaptable to the narrative function. The choice of the point of view of narration, tone of voice, type of media to employ and duration of the story defined the narrative scheme, as shown below in Figure 2. This scheme has been essential for crafting the entire story plot that has mixed archeological facts with plausible fictional elements in order to make the experience more pleasant for visitors. The whole script has been then divided into modules, or rather, self-contained micro-stories with no main start or ending and visualized throughout the storyboards. Notes of graphic effects, animations or sound effects

were taken on these boards, making the development of virtual contents and the recording of dialogue tracks simpler.

- **Point of view of narration**: 1st person;
- **Tone of voice**: solemn (heroic) but with simple words;
- **Points of interest of the narrative**: significant events in the Warrior's life;
- **Narration**: modular;
- **Type of media**: audio–video (MR + graphic–visual and sound elements);
- **Duration of the narration**: about 30 sec – 45 sec per narration.

Figure 2: *main point of the narrative scheme defined*

4.2 Virtual content and mixed reality application

This hybrid experience prototype has been developed only on the single narrative module in which the Capestrano's Warrior describes his life as a soldier chief and his war equipment, delving into its social-symbolic meaning in Vestini's culture. Both app and virtual contents have been designed referring to several HBIM workflows[38, 39, 40, 41, 42, 43, 44, 45] then adding Mixed Reality features. Five main steps have been involved during the process: scanning the statue (or archaeological find), elaborating 3D digital reference, modeling virtual objects and scene effects, creating Mixed Reality tracker, developing the prototype app. The Warrior's statue surface geometry has been captured through photogrammetry workflow creating a digital reference[46, 47, 48] upon modeling a 3D reconstruction of his war equipment and armor. The digital reference has been properly refined allowing it to be exported as high-poly mesh on which the war equipment has been modeled, adapting the pipeline of video game production[49, 50, 51] and applying the retopology process directly to this high-poly mesh of the statue. The final output was a low poly model of the equipment already optimised for the texturing phase and real-time rendering as illustrated in Figure 3.
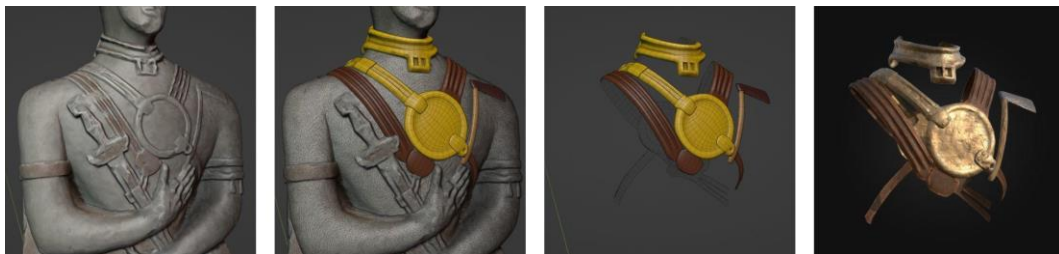

Figure 3: *Main step of the modeling and final result (on the right)*

Thanks to dedicated softwares (eg. AR Foundation, Vuforia), the object tracking application has detected the most relevant data of the high-poly mesh storing them into a new 3D reference mesh, already optimized for real-time experience development purposes. In addition, this application has also created an outline picture of the statute that was necessary both for guiding the user during the experience and triggering virtual contents. All these output components have been gathered into a game engine in which it has been possible to properly arrange the war equipment reconstruction on the 3D reference mesh creating also armor components animation and visual effects according to storyboards. Sound effects and voiceover have been added in the same scene and processed to create spatial sound effects reactive to user position, movement and point of view. In conclusion, the graphic user interface has been designed allowing the user/visitor to trigger the hybrid narrative experience by pointing the smartphone camera to the Warrior's statue until the outline on the screen matches the statue one. In doing this set of actions, the system recalls the digital reference stored in it and tracks the virtual layer to the physical object with high accuracy. While the tracking system is running, the visitor can listen to the warrior's story exploring both virtual and physical

dimension, influencing with its position or movement the sound effects and creating an unique experience based on its point of view.

5   Visual communication design

As stated during paragraph 3, MANA lacks a meaningful visual identity, so the purpose of this visual design project was to make MANA's communication recognisable to visitors while ensuring consistency and clarity over physical and digital touchpoints. The logo on the left is the current one of the MANdA and it is the only element available but, at the same time, it doesn't represent the institution. Through the comparison shown in Figure 4, it is possible to see how the proposed logo on the right, redesigned from scratch, reveals a direct reference to the Warrior of Capestrano statue through its outline, helping to establish a direct connection between the museum and its most important element. Moreover, the pictogram creates a direct visual connection to the museum and its exhibit, along with the logotype that presents the new name MANA, previously MANDA.

Figure 4: *The actual museum logo, on the left, and the redesigned logo, on the right*

A new key visual based on Memphis style has been designed, mixing geometric elements, bright flat colors and pictures of archaeological finds, as shown in figure 5. The contrast between digital and physical elements creates pleasant graphics effects while embodies the concept of a hybrid museum and, in the meanwhile, it is possible to set different composition and graphic material starting from the same kind of visual resources.

Figure 5: *Graphic composition obtained by mixing the new visual elements*

5.1   The website

As shown in Figure 6, the website on the right was designed following the visual communication principles observed in the previous paragraph that clearly present the new visual identity. The user experience has been designed in order to give more relevance to interactive and digital storytelling contents. The current landing page structure on the left was replaced by a multipage system that includes a collections page, an events page and museum virtual experience pages. Each archaeological find digitalized is available through an interactive 3D player on proper dedicated pages and their information is provided through the narrative approach, according to the workflow described in paragraph 4.1.
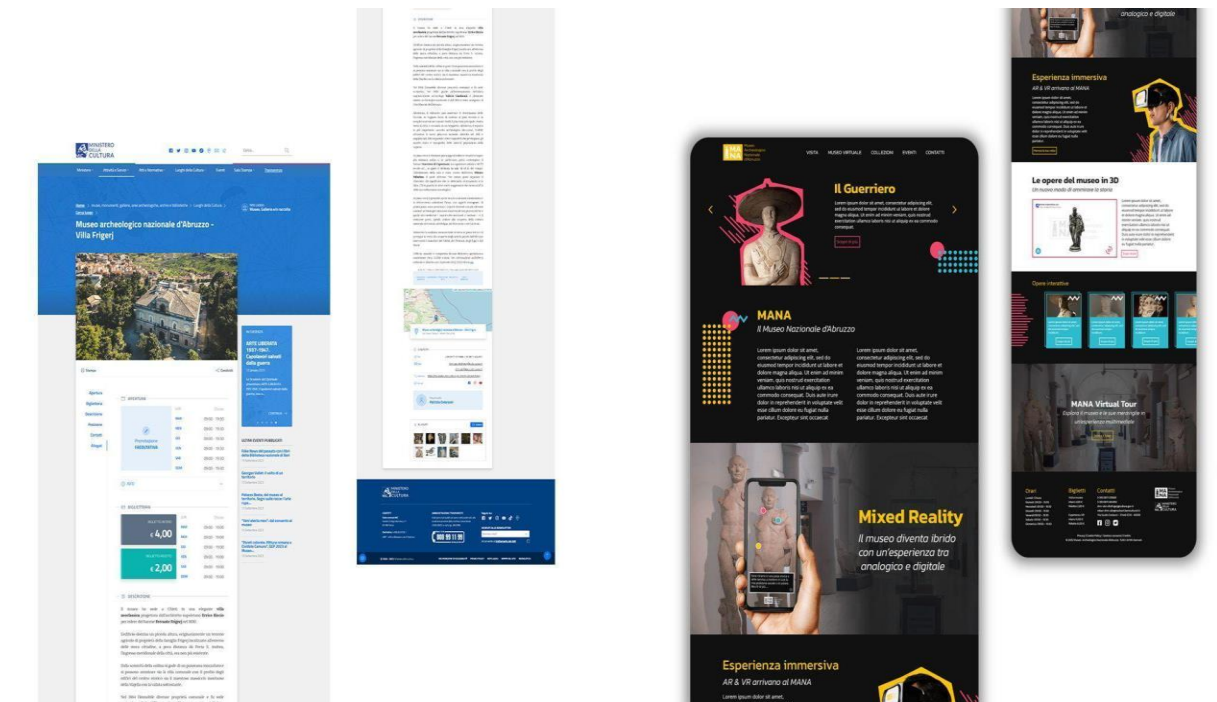

Figure 6: *The actual museum website, on the left, and the redesigned one, on the right*

5.2   The mobile app

MANA doesn't currently have any mobile app, so it was designed from scratch focusing on its strategic relevance for hybrid experiences, as shown in Figure 7. Other virtual and multimedia contents about the exhibit are available on the app, along with the audio guides and narrative visit paths. The event section shows updates on new exhibitions working as a booking and ticketing system, thus providing both communication and experiential function.

Figure 7: *Main screen of visit section user flow*

6   Conclusions

The introductory analysis of evolving dynamics between technology and social behaviors allowed us to understand the principles on which the transformation of cultural heritage museums has taken place in the past years. Museum visit experience attention has been shifted from collection to visitors' agency employing digital technologies as media to rethink the dialogue between visitors and exhibit, and besides, to enhance museum communication towards its audience. These approach changes have been found across many cultural heritage museum institutions examined during the qualitative comparative analysis employed in this proposed design approach, observing parallelisms in communication and experience innovation strategies and providing valuable insights to address the Museo Nazionale Archeologico d'Abruzzo challenges. Nevertheless, the necessity of employing a holistic approach has been acknowledged to design an effective museum communication and visitor's experience for this specific case study, while leveraging any synergic interactions among different project elements. It follows that both the narrative hybrid experience and the redesign of MANA's communication, in particular its digital touchpoints, are interconnected aspects and necessary to each other to comply with the project's goals and visitors' expectation as described in paragraph 2. The narrative hybrid experience leaned more towards an AR experience rather than an MR one due to limited resources but, despite this, it still effectively embodies the proposed idea and vision of a hybrid museum experience. In conclusion, the design path and development workflows presented in this paper offer practical guidance for designers who approach to communication and experience museum innovation, providing valuable principles for developing project interventions. Each workflow can be repeated using the same technology set that allows seamless integration of new content while minimizing design and management resources.

7   Declarations

7.1   Acknowledgements

7.2   Publisher's Note

AIJR remains neutral with regard to jurisdictional claims in in published maps and institutional affiliations.

How to Cite

Alessandro Mucci (2024). Systemic Design Path to Innovate Italian Archaeological Museums into Hybrid Museums. *AIJR Proceedings*, 187-196. https://doi.org/10.21467/proceedings.168.21

References

[1]   Black, G., (2011). *Transforming Museums in the Twenty-first Century (1st ed.)*, New York (USA) & London (UK): Routledge, ISBN: 978-0-415-61573-0, https://doi.org/10.4324/9780203150061;

[2]   Hooper-Greenhill, E., Macdonald, S. (Ed.), (2006). *"Studying visitors," in A Companion to Museum Studies*, Oxford (UK): Blackwell Publishing, pp. 362–376, ISBN: 9780470996836, https://doi.org/10.1002/9780470996836.ch22;

[3]   Giannini, T., Bowen, J.P., (2022). *Museums and Digital Culture: From Reality to Digitality in the Age of COVID-19*, Heritage, 5(1), pp. 192-214, https://doi.org/10.3390/heritage5010011;

[4]   Giannini, T., Bowen, J. P., (2021). *Museums at the Crossroads: Between Digitality, Reality, and COVID-19*, https://doi.org/10.31235/osf.io/2g567;

[5]   Barbanera, M., (2018), *Dal Museo–Tempio al Museo–Agorà: ovvero come non perdere la generazione 'Google'*, pp 171-176, Roma (Italy): E.S.S. Editorial Service System, ISBN: 978-88-8444-182-9, https://hdl.handle.net/11573/1131816;

[6]   Benkler, Y., (2006), *The Wealth of Networks: How Social Production Transforms Markets and Freedom*, New Haven (USA): Yale university Press, ISBN: 9780300125771;

[7]   Benkler, Y., Nissenbaum, H.F., (2006), *Commons-Based Peer Production and Virtue*. Journal of Political Philosophy, 14(4), https://ssrn.com/abstract=2567434;

[8]   [8] Arvidsson, A., Delfanti, A. (2013). *Introduzione ai media digitali,* pp. 53-73, Bologna (Italy): Il Mulino, https://hdl.handle.net/2434/221099;

[9]   Toffler, A., (1980). *The third wave*, New York (USA): Morrow.

[10]   [10] Chatterjee, S., Mariani, M., Fosso Wamba, S., (2023). *Prosumers' intention to co-create business value and the moderating role of digital media usage*, Journal of Business Research, 163(8), https://doi.org/10.1016/j.jbusres.2023.113920;

[11]   Jenkins, H., (2007), *Cultura convergente*, Milano (Italy): Apogeo, ISBN: 8850326297;

[12]   Milgram, P., Kishino, F., (1994). *A Taxonomy of Mixed Reality Visual Displays*, IEICE Trans. Information Systems, vol. E77-D, no. 12, pp. 1321-1329;

[13]   Giannini, T., Bowen, J. P., (2019). *Museums and Digital Culture. New Perspectives and Research*. New York (USA): Springer, ISBN: 978-3-319-97457-6, https://doi.org/10.1007/978-3-319-97457-6;

[14]   Simon, N., (2010). *The Participatory Museum,* Santa Cruz (USA): Museum 2.0, ISBN: 978-0615346502;

[15]   Hooper-Greenhill, E., (2000). *Changing Values in the Art Museum: rethinking communication and learning*, International Journal of Heritage Studies, 6(1), pp. 9-31, https://doi.org/10.1080/135272500363715;

[16]   Waern, A., Løvlie, A. S. (Eds.). (2022). *Hybrid Museum Experiences: Theory and Design*, Amsterdam University Press; https://doi.org/10.2307/j.ctv2cxx8x6;

[17]   Løvlie, A. S., Waern, A. (2022). Introduction. In A. S. Løvlie & A. Waern (Eds.), *Hybrid Museum Experiences: Theory and Design*, pp. 17–30, Amsterdam University Press. https://doi.org/10.2307/j.ctv2cxx8x6.4;

[18]   Bonacini, E., (2014). *La valorizzazione digitale del patrimonio culturale in Europa e in Italia. Forme di fruizione e di valorizzazione museale attraverso le nuove tecnologie e i social media. Una proposta di turismo wireless per Catania,* pp. 48-52, Catania (Italy): Università di Catania, http://dx.doi.org/10.13140/RG.2.1.2965.3840;

[19]   Direzione Generale Musei, (2019). *Piano Triennale per la Digitalizzazione e l'Innovazione dei Musei,* (Italy), http://musei.beniculturali.it/notizie/notifiche/piano-triennale-per-la-digitalizzazione-e-linnovazione-dei-musei;

[20]   Pirrelli, M., (2022), *Corte dei Conti: la digitalizzazione della cultura ancora in ritardo*, ilSole24Ore, https://www.ilsole24ore.com/art/corte-conti-digitalizzazione-cultura-ancora-ritardo-AEfgcUBC;

[21]   Mandarano, N. (2019). *Musei e media digitali*, Roma (Italy): Carocci editore, ISBN: 9788843095988;

[22]   Parco Archeologico dell'Appia Antica, Rome, https://www.parcoarcheologicoappiaantica.it/digital/;

[23]   Museo Egizio, Turin, https://museoegizio.it/scopri/tour-virtuali/;

[24]   Muséum national d'Histoire naturelle, Paris, https://www.mnhn.fr/fr/nos-expositions;

[25]   Museo Nazionale d'Abruzzo, L'Aquila, https://museonazionaledabruzzo.cultura.gov.it/;

[26]   Musei Civici di Pavia, Pavia, https://collezioni.museicivici.pavia.it/cast/#/;

[27]   Museo Nazionale Romano - Palazzo Massimo, Rome, https://museonazionaleromano.beniculturali.it/palazzo-massimo/;

[28]   The British Museum, London, https://www.britishmuseum.org/;

[29]   Schorch, P., (2014). *Cultural feelings and the making of meaning*, International Journal of Heritage Studies, 20(1), pp. 22-35, https://doi.org/10.1080/13527258.2012.709194;

[30]   Mason, R., Corsane, G. (Ed.), (2005). *Museums, galleries and heritage: Sites of meaning-making and communication*, pp. 200-214, New York (USA) & London (UK): Routledge, ISBN: 9780415289467;

[31]   Kamel Ahmed, E., (2015). *What to conserve? Heritage, memory, and management of meanings*. International Journal of Architectural Research, 9(1), pp. 67-76, https://clok.uclan.ac.uk/id/eprint/11743;

[32]   Black, G., (2005). *The Engaging Museum: Developing Museums for Visitor Involvement (1st ed.)*, New York (USA) & London (UK): Routledge, ISBN: 9780203559277, https://doi.org/10.4324/9780203559277;

[33]   ICOM Italia, (2019). Schema per la Web Strategy museale WSS, (Italy), https://www.icom-italia.org/schema-web-strategy-museale-wss/;

[34]   Pessina, A., Simongini, G., (2011). *Al di là del tempo. Mimmo Paladino e il guerriero di Capestrano. La nuova sala*, Torino (Italy): Allemandi, EAN: 9788842219767;

[35]   Lambert, J., & Hessler, B., (2018). *Digital Storytelling: Capturing lives, Creating Community (5th ed.)*, New York (USA): Routledge, https://doi.org/10.4324/9781351266369;

[36]   Agostini, S., Cosentino, S., d'Ercole, V., La Regina, A., Martellone, A., Ruggeri, M., Staffa, A.R., Tuteri, R., Franchi Dell'orto, L.(Ed.), (2010). *Pinna Vestinorum e il popolo dei Vestini - Storia e civiltà di Penne - Lucio Marcotullio - Vol 1,* pp. 52-247, Roma (Italy): "L'Erma" di Bretschneider, ISBN: 978-88-8265-539-6;

[37]   Adinolfi, G., Agostini, S., Belfiore, V., Carmagnola, R., Carniel, M.V., d'Ercole, V., D'Errico, R., Di Antonio, M.G., Di Valerio, E., Masci, M.E., Mancini, M.C., Menozzi, O., Palumbo, D., Zelante, I., (2020). *Progetto ARS - Archeometria e Remote Sensing per la diagnostica delle Sculture Italiche dall'Abruzzo: risultati preliminari,* Frankfurter elektronische Rundschau zur Altertumskunde, 40, pp 1-10, https://doi.org/10.21248/fera.40.284;

[38]   Murphy, M., McGovern, E., Pavia, S., (2009). *Historic building information modelling (HBIM)*, Structural Survey, 27, pp 311-327, ISSN: 0263-080X, https://doi.org/10.1108/02630800910985108;

[39]   Oreni, D., Brumana, R., Della Torre, S., Banfi, F., Barazzetti, L., Previtali, M., (2014). *Survey turned into HBIM: the restoration and the work involved concerning the Basilica di Collemaggio after the earthquake (L'Aquila)*, ISPRS annals of the photogrammetry, remote sensing and spatial information sciences, 2(5), pp. 267-273, https://doi.org/10.5194/isprsannals-II-5-267-2014;

[40]   Pepe, M., Costantino, D., Restuccia Garofalo, A., (2020). *An Efficient Pipeline to Obtain 3D Model for HBIM and Structural Analysis Purposes from 3D Point Clouds*, Applied Sciences, 10(4):1235, https://doi.org/10.3390/app10041235;

[41]   Banfi, F., (2020). *HBIM, 3D drawing and virtual reality for archaeological sites and ancient ruins*, Virtual Archaeology Review, 11(23), pp. 16–33. https://doi.org/10.4995/var.2020.12416;

[42]   England, H., (2017). *BIM for heritage: Developing a historic building information model*, Swindon (UK): Historic England, https://historicengland.org.uk/advice/technical-advice/recording-heritage/;

[43]   Martelli, L., Calcerano, F., Gigliarelli, E., (2022). *Methodology for an HBIM workflow focused on the representation of construction systems of built heritage*, Journal of Cultural Heritage, 55, pp. 277-289, ISSN 1296-2074, https://doi.org/10.1016/j.culher.2022.03.016;

[44]   Ma Y-P., (2021). *Extending 3D-GIS District Models and BIM-Based Building Models into Computer Gaming Environment for Better Workflow of Cultural Heritage Conservation*, Applied Sciences, 11(5):2101, https://doi.org/10.3390/app11052101;

[45]   Yan, W., Culp, C., & Graf, R., (2011). *Integrating BIM and gaming for real-time interactive architectural visualization,* Automation in Construction, 20(4), 446-458, https://doi.org/10.1016/j.autcon.2010.11.013;

[46]   England, H., (2017). *Photogrammetric Applications for Cultural Heritage: Guidance for Good Practice*, Swindon (UK): Historic England, https://historicengland.org.uk/advice/technical-advice/recording-heritage/;

[47]   Merlo, A., Sánchez Belenguer, C., Vendrell Vidal, E., Fantini, F., Aliperta, A., (2013). *3d Model Visualization Enhancements In Real-Time Game Engines*, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XL-5/W1, pp. 181–188, https://doi.org/10.5194/isprsarchives-XL-5-W1-181-2013;

[48]   Guidi, G., Russo, M., Beraldin, J.-A., (2010). *Acquisizione 3D e modellazione poligonale*, Milano (Italy): McGraw-Hill, ISBN: 9788838665318, https://hdl.handle.net/11573/905502;

[49]   Dunlop, R., (2014). *Production pipeline fundamentals for Film and Games (1st ed)*, pp 3-20, New York (USA): Routledge, ISBN: 9780415812290, https://doi.org/10.4324/9781315858272;

[50]   Lengyel, E., (2010). *Game Engine Gems, Vol. 1*, pp 11-22, Sudbury (USA): Jones and Bartlett Publishers, ISBN: 978-0-7637-7888-0;

[51]   Kumar, A., (2020). *Beginning PBR Texturing - Learn Physically Based Rendering with Allegorithmic's Substance Painter*, pp 31-42, California (USA): Apress Berkeley, ISBN: 978-1-4842-5898-9, https://doi.org/10.1007/978-1-4842-5899-6;